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NASA TECH BRIEF

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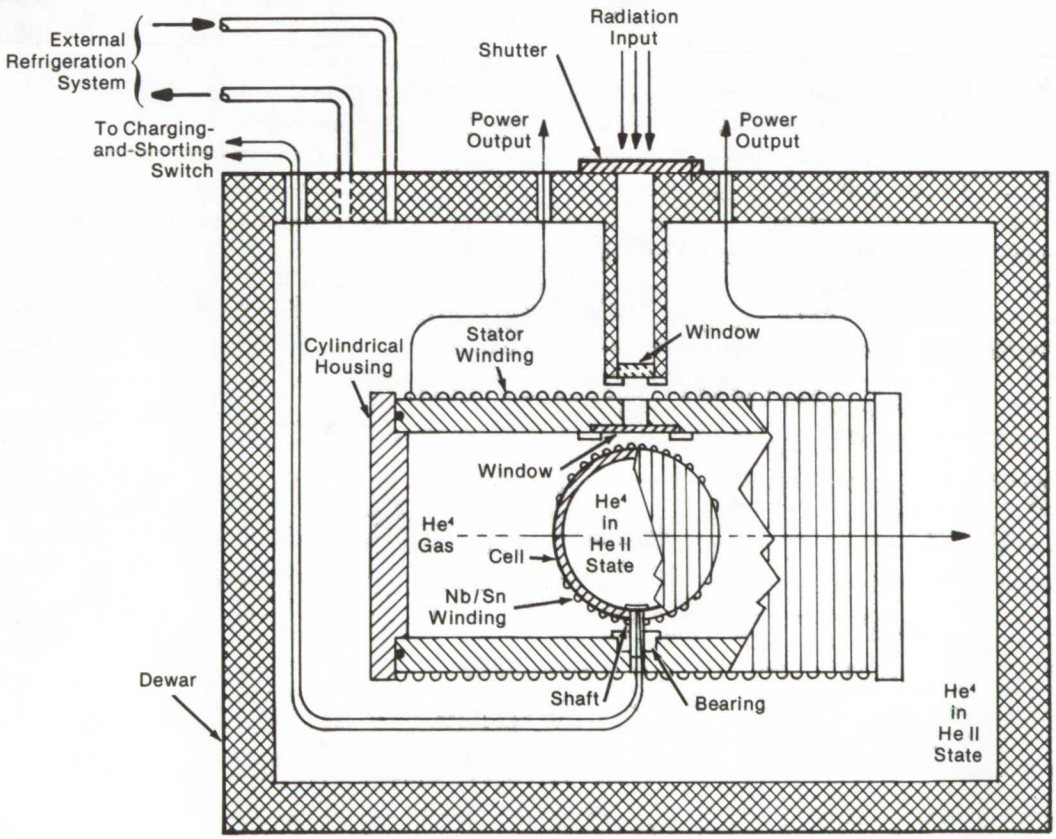
Heat-Operated Cryogenic Electrical Generator

Semiconductor solar cells are inadequate for environments at great distances from the Sun. Not enough solar energy reaches the cells to provide efficient generation of electrical power. Radioactive sources can be used, but they have thick shielding which makes them heavy. An alternate approach is to use a heat-operated cryogenic electrical generator.

The generator operation is based upon unusual hydrodynamic properties exhibited by liquid helium below the superfluid critical point, which is about 2.17 K for He^4. Below that temperature, the liquid behaves as though it is a mixture of two interpenetrating fluids, each with its own density and velocity field. When transition takes place between the superfluid and normal states, the conservation of momentum is always balanced by the normal fluid.

The proposed generator as shown consists of a spherically-shaped thin-wall cell filled with aluminum oxide powder of a known fine grain size and liquid helium. The entire device is contained within a Dewar which is filled with liquid helium in the He II (superfluid) state. The liquid helium is maintained in this temperature region by external refrigeration.



Cryogenic Electrical Generator

(continued overleaf)

The cell is supported by a shaft which is journaled for rotation on a bearing. The bearing is mounted within a closed cylindrical housing which is supported within the Dewar. The housing is filled with gaseous helium which surrounds the cell to act as a heat-transfer medium between the liquid helium of the Dewar and the liquid helium in the cell.

The exterior of the cell is wound with a niobium/tin (Nb/Sn) alloy winding which is superconducting at the temperature of the cell. Once the superconducting winding is charged, the persistent current flowing in the winding produces a magnetic field similar to that of a permanent magnet but of greater strength. The winding surrounds the exterior of the cell, as indicated, so that its lines of force are perpendicular to the axis of rotation of the cell.

A stator winding is coiled around the cylindrical housing with its conductors perpendicular to the central axis of the cylinder, and hence perpendicular to the direction of rotation of the lines of force of the magnet coil of the cell. When the cell rotates about its axis, the lines of force emanating from its magnetic field cut through the stator-winding conductors. Once the magnetic field is set up in the cell winding, its field does not vary. Hence the lines of force cannot cut the stator conductors unless the cell moves about its axis, since otherwise there is no time-varying magnetic field.

When the cell is set into motion, its magnetic field rotates with it, inducing current flow in the stator winding which can be supplied to an external load. The direction of the induced current depends on the direction of the cell rotation.

The generator operates as follows: The superconducting winding is charged through the leads connected through the shaft from an external source to set the persistent current to maximum. Once charged, the external source is disconnected from the superconducting winding, and the winding is shorted to allow the flow of the persistent current. Then the cell temperature is lowered to set to maximum the angular momentum of the superfluid component of the helium within the cell.

Next, the cell temperature is raised by exposing it to some heat source such as solar energy or, when not available, to some background temperature of approximately 4 K, which is sufficiently high to provide the necessary heat input. The heat input is alternated by the shutter. This input in the form of visible or IR (infrared) radiation is admitted through a window in the Dewar and another window in the housing. With the shutter blocking the radiation input, the cell temperature is lowered, causing the cell to rotate in one direction. With the shutter opened, the cell temperature is raised, making the cell rotate in the opposite direction. The resulting ac power is fed through power output lines.

Note:

Requests for further information may be directed to:

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Reference: TSP75-10116

Patent status:

This invention has been patented by NASA (U. S. Patent No. 3,875,435). Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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Categories: 03 (Physical Sciences)
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